C. 1 JUN 2 72
H H7-4 0V HR16-2B
HR20-10B HR40-5B
HR40-7.5B HR60-2.5B
HR60-5B
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INSTRUCTION MANUAL

MODEL HH50-1

SILICON QUARTER RACK SERIES

TRANSISTORIZED POWER SUPPLY

TRYGON ELECTRONICS
SUBSIDIARY
SYSTRON DONNER
CORPORATION

1200 SHAMES DRIVE • WESTBURY, N.Y. 11590

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NOTICE

This Instruction Manual provides general characteristics, operating procedures, theory of operation, maintenance and calibration procedures and includes a complete schematic, troubleshooting guide and parts list pages for the model(s) listed on the front cover.

Any questions concerning this documentation should be directed to the Publications Dept., Trygon Electronics Inc., 1200 Shames Drive, Westbury, N. Y., 11590.

Questions concerning the operation and application of Trygon power supplies should be directed to the Applications Engineering Dept., at the above address.

MEASUREMENT OF REGULATION AND RIPPLE

The specifications cited herein for regulation and ripple can be readily attained on every Trygon power supply, provided the proper method of measurement is employed. The major consideration is that the highly stable meter and oscilloscope, specified in the calibration section test procedures, must be connected to the sensing terminals and not the load terminals. The reason for this precaution is that the voltage drop between the load terminals and sensing terminals will yield an inacurate regulation ripple measurement.

TABLE OF CONTENTS

SECTION I - DESCRIPTION

PARAGRAPH	TITLE	PAGE
1.1	INTRODUCTION	1-1
1.2	GENERAL FEATURES	1-1
1.3	PRECAUTIONARY MEASURES	1-3
1.4	SPECIFICATIONS	1-4

SECTION II - INSTALLATION AND OPERATION

PARAGRAPH	TITLE	PAGE
2.1	MECHANICAL INSTALLATION	2-1
2.2	ELECTRICAL CONNECTIONS	2-2
2.3	CONTROLS	2-4
2.4	OPERATION	2-4

SECTION III - THEORY OF OPERATION

PARAGRAPH	TITLE	PAGE
3.1	GENERAL	3-1
3.2	CIRCUIT ANALYSIS	3-1
3.3	OPTIONAL FEATURES	3-3

SECTION IV - MAINTENANCE

PARAGRAPH	TITLE	PAGE
4.1	GENERAL	4-1
4.2	LOADS AND INTERCONNECTIONS	4-1
4.3	TROUBLESHOOTING	4-2

TABLE OF CONTENTS

SECTION V - CALIBRATION

PARAGRAPH	TITLE	PAGE
5.1	GENERAL	5-1
5.2	TEST EQUIPMENT REQUIRED	5-1
5.3	CALIBRATION PROCEDURE	5-1

APPENDICES

LIST OF ELECTRICAL PARTS
COMPONENT BOARD LAYOUT
SCHEMATIC DIAGRAM

LIST OF TABLES

TABLE	TITLE	PAGE
2-1	AC INPUT WIRE SIZE	2-2
2-2	SHORTING LINK APPLICATION, REAR PANEL	2-3
2-3	FRONT PANEL CONTROLS	2-4

LIST OF ILLUSTRATIONS

FIGURE	TITLE	PAGE
2-1	SET UP FOR PARALLEL OPERATION	2-7
3-1	BLOCK DIAGRAM	3-4
5-1	CONSTANT VOLTAGE OPERATION	5-6
5-2	CONSTANT CURRENT OPERATION	5-6

SECTION I - DESCRIPTION

1.1 INTRODUCTION

The Silicon Quarter Rack Series power supply is a flexible and dependable source of D.C. power, which can be used to meet a variety of needs. These needs may range in scope from inspection and production testing, to laboratory bench testing and systems applications.

The wide range of outputs available makes this unit well suited for use as a basic laboratory power source. The ability to provide power packaged in minimum space with high reliability meets the demands of most systems requirements.

All components used in the construction of the Silicon Quarter Rack units are of the highest quality available, and have been subjected to 100% incoming inspection.

Each electrolytic filter capacitor is of computer grade, and has been quoted by the manufacturer as having a life expectancy exceeding ten (10) years. All silicon transistors have been "derated" and temperature aged to provide high reliability. All rectifiers are hermetically sealed silicon units, and all Zener diodes have been temperature stabilized.

1.2 GENERAL FEATURES

Output, Sensing and Remote Programming terminals are located on a terminal board mounted on the rear panel of the unit. The AC power switch, AC pilot lamp, current mode indicator lamp, current and voltage controls and appropriate metering devices are all located on the front panel. For convenience, additional output terminals have been provided on the front panel.

1.2.1 Constant Voltage Mode

A constant voltage is maintained across the output terminals at any preset value from zero to rated voltage output, provided that the load does not draw more than either the rated output current or more than the preset limiting current value determined by the front panel current control settings.

1.2.2 Constant Current Mode

Constant current operation is achieved by maintaining a constant voltage across an internal current sensing resistor. An automatic cross over network changes the mode of operation from Constant Voltage to Constant Current when the current demand reaches that of the preset current adjust control. The point at which the operating mode automatically changes is a function of variations in load conditions. The cross over point is adjustable, and can be established anywhere within the current and voltage range of the unit.

1.2.3 Automatic Current Limiting

Short circuit protection is provided by the Automatic Current Limiting circuit which limits the maximum output current under all load conditions. The point at which automatic current limiting occurs is variable, and may be selected anywhere between 5% of the rated current output and maximum rated current output of the unit. In the event of a short circuit, the output voltage will drop to zero, and will return to its previous level only upon removal of the short circuit.

1.2.4 Automatic Overvoltage Protection (Optional Feature)

Automatic Overvoltage (OV) protection is available as an option wherein special circuitry automatically tracks the programmed output voltage and prevents it from exceeding this output voltage. The voltage differential that will cause the OV to trip is approximately 10% or 1.5 volts above the programmed

1.2.4 Automatic Overvoltage Protection (Optional Feature)(Cont'd)

voltage. An internal sensitivity control is provided to desensitize the overvoltage protection circuit.

1.2.5 Remote Programming

Remote Programming is provided in the voltage mode of operation, and may be utilized over the entire voltage range of the unit. The scale factor for Remote Voltage Programming is 100 ohms per volt.

1.3 PRECAUTIONARY MEASURES

1.3.1 Wire Size

To assure proper regulation under all load conditions, and to prevent severe distortions of the AC line voltage, it is very important to take into consideration the physical size and current handling capabilities of the input power line. Serious losses in regulation and an increase in ripple may result from underrated or overloaded AC input lines. The maximum AC impedance from the breaker box to the power supply input should not exceed 0.75 ohms.

1.3.2 Voltage Regulator and Inverter Inputs

Do not use voltage regulators or inverters as a primary power source. The outputs of these devices are usually not sinusoidal in nature, and if used as the AC source for the power supply, will cause serious loss of regulation of the power supply output. Capacitive input filtering used for semiconductor power supplies requires charging to the peak of the rectified AC wave which non-sinusoidal AC sources cannot provide.

1.3.3 Variable Transformer Input

If a variable transformer is to be used to test the power supply for low and high AC line operation, it must be able to

1.3.3 Variable Transformer Input (Cont'd)

supply at least twice the VA requirements of the power supply and load.

1.3.4 Systems Considerations

In systems applications it is recommended that each power supply input power line be run separately to the AC distribution box, in order to minimize cross coupling and interaction between equipment. Do not run sensitive signal leads such as the remote sensing leads in the same cable as the AC input without shielding. It is strongly recommended that the AC input cables should not be run in close proximity to the output load cable leads, if minimum ripple is desired.

1.3.5 Terminal Post Resistance

All terminals and shorting links serving Outputs, Sensing and Programming must be securely tightened before use. Serious loss of regulation and an increase in ripple can result due to a voltage drop caused by loose terminals and shorting links.

1.4 SPECIFICATIONS

Electrical and physical specifications appear on the following Trygon Specification Sheet.

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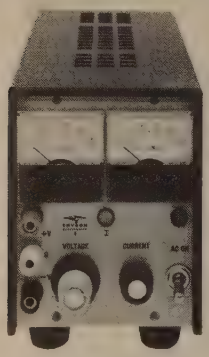
HH Quarter Rack Series
Constant Voltage/Constant Current



HH Series

Features

- All Silicon Design
- Compact Quarter Rack Construction
- +60°C Operation Without Derating
- Remote Voltage Programming
- Remote Sensing
- Series or Parallel Operation
- No Turn On/Turn Off Transients
- Overvoltage Protection Option

Description

The Trygon Silicon Quarter Rack Series units are lightweight, compact, versatile power supplies designed for laboratory, factory test and systems applications. Their convenient quarter rack size permits them to be used in practically all areas of the laboratory. Utilizing all silicon semiconductors, these units will operate at their maximum temperature without derating.

Constant Voltage and Constant Current operation is provided with automatic crossover from one mode into the other. In the voltage mode, adjustable current limiting is provided while the current mode provides adjustable voltage limiting. A mode indicator light on the front panel indicates when the unit is operating in the constant current or current limiting mode. All units in this series have provisions for remote programming of voltage.

	Output		
Model	Volts	Amps	*Impedance DC-1 kHz
HH7-4 OV	0-7	0-4	0.002
HH15-3	0-15	0-3	0.002
HH32-1.5	0-32	0-1.5	0.002
HH50-1	0-50	0-1	0.002
HH160-300	0-160	0-0.3	0.002

*Nominal

Electrical Specifications

CONSTANT VOLTAGE MODE WITH ADJUSTABLE CURRENT LIMITING

Input:	105-125 VAC, 47-420 Hz. (200-240 VAC available).
Output:	Floating; isolated from ground, 300 VDC max.
Regulation, Line:	0.01% or 2 mV,* for 105-125 VAC line change, at any output within specifications.
Regulation, Load:	0.01% or 3 mV*, no load to full load at any output within specifications.
Ripple:	Less than 0.5 mV RMS.
Stability:	0.05% or 10 mV*, for 8 hours after warm-up. Measured at constant line voltage, load and ambient temperature.
Temperature Coefficient:	(0.02% + 400 μV)/°C.
High Stability Option (X):	0.01% or 2 mV* with a T.C. of (0.01% + 100 μV)/°C.
Temperature Range:	0 to + 60°C.
Recovery Time:	25 microseconds to within 0.05% or 15 mV* of output voltage, for 100% step change in rated load.
Short Circuit Protection:	Automatic Adjustable Current Limiting (ACL) variable from 5% to 100% of rated current.
AC Power Input Protection:	Fuse.
Remote Programming:	All units remotely programmable over output voltage range. Scale factor 100 ohms/volt.
Remote Sensing:	Maintains rated regulation directly at the load. Maximum line drop 0.5 volts per leg.
Voltage Adjustment Range:	Continuously adjustable concentric vernier controls.
Overvoltage Protection: (Internal Option)	Automatic fast acting overvoltage protection tracks the preset output voltage.

CONSTANT CURRENT MODE WITH ADJUSTABLE VOLTAGE LIMITING

Current Output:	5% to rated current output.
Voltage Compliance:	0 to rated output voltage.
Regulation:	0.5% I_{rated} over full voltage range or for 105-125 VAC line change.
Ripple:	0.25% or 5 mA.*
Stability:	0.25% I_{rated}.
Temperature Coefficient:	0.1% I_{rated}/°C.

General and Physical Specifications

Design Principle:	Precision Series Pass Regulation.
Operational Modes:	Constant Voltage with adjustable current limiting; Constant Current with adjustable voltage limiting; Automatic Crossover.
Mode Indicator:	Front panel mode indicator light indicates when supply is operating in the constant current or current limiting mode.
Controls:	
Voltage:	Coarse and Fine; 0 to rated output; front panel.
Current:	5% to 100% of rated output; front panel.
Input Power:	Front panel switch and indicator.
Metering:	
Voltage:	Front panel voltmeter.
Current:	Front panel ammeter.
Terminals:	
Front Panel:	Positive Output (+ V); Negative Output (— V); Ground (G).
Rear Panel:	(1) Negative Output — V; (2) Negative Sensing — S; (3-4-5) Remote Voltage Programming RVP; (6) Positive Sensing + S; (7) Positive Output + V; (8) Ground G.
Rack Mounting:	RHH-4 (mounts 4 HH units), RHH-3 (mounts 2 HH units and 1 HR unit). Blank filler panel PQ-1 also available.
Size:	4¼" W x 5" H x 15" D.
Weight:	13 lbs.

*Whichever is greater.

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TRYGON ELECTRONICS
SUBSIDIARY

SYSTRON DONNER

HR(B) Medium Power Half Rack Series
Constant Voltage/Constant Current

HR(B) Series

Features

- All Silicon Design
- Automatic Short Circuit Protection
- Remote Voltage Programming
- Remote Sensing
- No Turn On/Turn Off Transients
- Overvoltage Protection Option

Description

The Trygon All Silicon Medium Power Half Rack Series units are designed for laboratory, bench, test, inspection, production and systems applications. Their unique design provides operating flexibility and high reliability at high power output levels.

	Output			
Model	Volts	Amps	*Impedance DC-1 kHz	Weight (lbs.)
HR20-10B	0-20	0-10	0.002	27
HR40-5B	0-40	0-5	0.004	26
HR40-7.5B	0-40	0-7.5	0.004	28
HR60-2.5B	0-60	0-2.5	0.008	23
HR60-5B	0-60	0-5	0.004	28
HR160-2B	0-160	0-2	0.008	28

*Nominal

Electrical Specifications

CONSTANT VOLTAGE MODE WITH ADJUSTABLE CURRENT LIMITING

Input: 105-125 VAC, 55-65 Hz (200-240 VAC, 50 or 400 Hz available).

Output: Floating; isolated from ground, 300 VDC max.

Regulation, Line: 0.01% or 2 mV,* for 105-125 VAC line change, at any output within specifications.

Regulation, Load: 0.01% or 3 mV,* no load to full load at any output within specifications.

Ripple: Less than 0.5 mV RMS.

Stability: 0.05% or 18 mV* for 8 hours after warm-up. Measured at constant line voltage, load and ambient temperature.

Temperature Coefficient: (0.02% + 400 μV)/°C.

High Stability Option (X): 0.01% or 2 mV* with a T.C. of (0.01% + 100 μV)/°C.

Temperature Range: — 20°C to + 60°C.

Recovery Time: Less than 50 microseconds to recover within 0.05% or 15 mV* of output voltage for 100% step change in rated load.

Short Circuit Protection: Automatic Adjustable Current Limiting (ACL) variable from 1% to 100% of rated current.

AC Power Input Protection: Fuse.

Remote Programming: All units remotely programmable over output voltage range. Scale factor approximately 100 ohms/volt.

Remote Sensing: Maintains rated regulation directly at the load. Maximum line drop 0.5 volts per leg.

Voltage Adjustment Range: Continuously adjustable concentric vernier controls.

Overvoltage Protection: (Internal Option) Automatic fast acting overvoltage protection tracks the preset output voltage.

CONSTANT CURRENT MODE WITH ADJUSTABLE VOLTAGE LIMITING

Current Range: 1% to rated current output.

Voltage Compliance: 0 to rated output voltage.

Regulation, Line: 0.5% I_{rated} for 105-125 VAC line change at any output within specifications.

Regulation, Load: 0.5% I_{rated} output current change for the maximum change in load resistance within the rated voltage compliance range.

Ripple: 0.25% or 5 mA*.

Stability: 0.5% I_{rated} for 8 hours after warm-up. Measured at constant line voltage, load and ambient temperature.

Temperature Coefficient: 0.1% I_{rated}/°C.

Remote Programming: Available on special order.

Trylink Precision Current Regulation Mode

Current Range: 1% to rated current output.

Voltage Compliance: 0 to rated output voltage.

Regulation Band: 0.1% I_{rated} total — line regulation, load regulation, and 8 hour stability (after warm-up) — for any input or output within specifications.

Ripple: 0.02% or 1 mA.*

Temperature Coefficient: 0.1% I_{rated}/°C.

General and Physical Specifications

Design Principle: Phase Controlled Pre-regulation with Precision Series Pass Regulation.

Operational Modes: Constant Voltage with adjustable current limiting; Constant Current with adjustable voltage limiting; Automatic Crossover; TRYLINK Precision Constant Current with adjustable voltage limiting.

Mode Indicator: Front panel mode indicator light indicates when supply is operating in the constant current or current limiting mode.

Controls:
- **Voltage:** Coarse and Fine; 0 to rated output; front panel.
- **Current:** Coarse and Fine; 1% I_{rated} to rated output; front panel.
- **Input Power:** Front panel switch and indicator.

Metering:
- **Voltage:** Front panel voltmeter.
- **Current:** Front panel ammeter.

Terminals:
- **Front Panel:** Positive Output (+ V); Negative Output (— V); Positive Sensing (+ S); Negative Sensing (— S); Ground (G).
- **Rear Panel:** (1) Ground G; (2-11) Trylink Connection I, C; (3) Spare; (4) Negative Output — V; (5) Negative Sensing — S; (6-7-8) Remote Voltage Programming RVP; (9) Positive Sensing + S; (10) Positive Output + V.

Rack Mounting: RPA-1 (Single), RPA-2 (Dual) rack adapters, mounts two units side by side; 5¼" rack height.

Size: 7¾" W x 4⅞" H x 14" D.

*Whichever is greater.

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SECTION II - INSTALLATION AND OPERATION

2.1 MECHANICAL INSTALLATION

2.1.1 General

If the Silicon Quarter Rack Series power supply is to be used in a portable bench type configuration, no special mechanical installation is required. However, if the unit is to be rack mounted, special rack mounting adapters must be used to secure the unit to the relay racks. Triple mount (RHH-3) and quadruple mount (RHH-4) rack panel adapters are available.

2.1.2 Rack Panel Adapter Mounting

1) Remove the 6-32 screws which fasten the cover to the power supply chassis.

2) Remove and rotate the cover so that the front is now facing to the rear.

3) Fasten the cover securely in position with the 6-32 screws previously removed.

4) Attach the handles to the Rack Panel Adapter.

5) Stand the Rack Panel Adapter in front of the power supply. In order to mount the power supply properly, the top of the Rack Panel Adapter must face up. The top is distinguishable from the bottom in that all the holes, including those for the handles, are in a straight row across the front of the Rack Panel Adapter.

6) Attach the power supply to the Rack Panel Adapter with the 6-32 screws and lock washers provided.

2.2 ELECTRICAL CONNECTIONS

2.2.1 Input, Power:

A heavy duty 3 wire line cord and molded plug with grounding prong provides a path for input power to the unit.

The power handling ability of the AC power lines feeding AC power to the line cord must be considered, as serious losses in regulation and substantial increases in ripple can occur as a result of insufficient power handling capacity of these lines. The AC impedance from the breaker box to the power supply input connector should not exceed 0.75 ohms. All AC power line connections must be securely tightened, and any movable electric contact surface (such as the wiper arm of a variable transformer) should be kept clear of impedance producing oxide coatings.

Care should be exercised in selecting the proper wire size for the AC input lines. The figures listed in Table 2-1 will serve as a guide in making this selection.

TABLE 2-1 - AC INPUT WIRE SIZE

Length of Run (Single Lead)	Wire Size (AWG Standards)
10 feet or less	12
10 feet to 20 feet	10
20 feet to 50 feet	8
50 feet to 100 feet	6

2.2.2 Output, Rear Panel

An eleven terminal barrier strip mounted on the rear panel provides output, sensing, programming and ground connections. Table 2-2 SHORTING LINK APPLICATION, REAR PANEL, lists the various shorting link connections required for any of the various modes of operation.

2.2.3 Output, Front Panel

Three binding post terminals mounted on the front panel provide output (+V and -V) and ground (G) connections.

2.2.4 Front or Rear Panel Output Selection

Output voltage is available from either the front or rear panel terminals. However, while regulation is maintained at both terminals, the rated regulation is available from the rear terminal only.

2.2.5 Shorting Link Application, Rear Panel

The power supply is shipped from the factory with shorting links in place across terminals 1 and 2, 4 and 5, and 6 and 7 of the rear panel barrier strip. In this configuration, and with the load connected across the rear panel output terminals, local sensing and programming operation from the rear panel is provided. Connections for other configurations are shown in Table 2-2 SHORTING LINK APPLICATION, REAR PANEL.

TABLE 2-2 SHORTING LINK APPLICATION, REAR PANEL

Selection	Function	Connections Required
1	Local Sensing Local Programming	1 and 2; 6 and 7 4 and 5
2	Local Sensing Remote Programming	1 and 2; 6 and 7 3 and 4; PGM resistor across 4 and 5
3	Remote Sensing Local Programming	1 and 2 connected at load (-) 6 and 7 connected at load (+) 4 and 5
4	Remote Sensing Remote Programming	1 and 2 connected at load (-) 6 and 7 connected at load (+) 3 and 4; PGM resistor across 4 and 5

NOTE: If terminals 1 and 2 or 6 and 7 are left open, the output will become unregulated.

2.3 CONTROLS

2.3.1 Front Panel

TABLE 2-3 - FRONT PANEL CONTROLS

SYMBOL	NAME	FUNCTION
S1	AC POWER	Toggle switch, controls input power.
R29	VOLTAGE ADJUST (Coarse)	Potentiometer, adjusts voltage output.
R30	VOLTAGE ADJUST (Vernier)	Potentiometer, adjusts voltage output.
R39	CURRENT ADJUST (Coarse)	Potentiometer, adjusts current.

2.3.2 Internal

All internal control settings have been factory preset, and require no additional adjusting. However, if it should become necessary to adjust any of the internal controls due to circuit changes caused by component aging or replacement, refer to the calibration section of this instruction manual.

2.4 OPERATION

2.4.1 Control Settings

Set all front panel controls fully CW so that unit will operate in the Voltage rather than Current Limiting mode.

2.4.2 Shorting Links

If Local Sensing rather than Remote Sensing operation is desired, ascertain that shorting links are in place across the appropriate terminals.

2.4.3 Grounding

Either side of the Output may be grounded, or the Output may be used in a floating condition.

2.4.4 Power On

Connect the line cord to a nominal AC input power source. Set POWER switch S1 to AC-ON, and observe that pilot lamp DS1 glows.

2.4.5 Warm-Up

No warm-up time is necessary to place the unit into operation. However, a 30 minute warm-up period is recommended to reach rated stability.

2.4.6 Series Operation

To operate two or more power supplies in a series configuration, connect the output of each power supply in series. When operating in this mode, it is necessary to adjust the output of each unit independently. The output voltage is equal to the sum of the voltage settings of each power supply.

2.4.7 Parallel Operation

Two power supplies may be connected in parallel when a greater current than obtainable from a single power supply is required. The supplies that are to be connected in parallel need not have equal ratings nor be from identical Trygon series. One of the two supplies should be set to a slightly higher output voltage than that required, and their respective plus and minus terminals connected together as shown in Figure 2-1.

2.4.7 Parallel Operation (Cont'd)

To achieve remote sensing, in parallel connected supplies, connect the sensing leads of the lower voltage supply to the load.

The following are some precautions which must be noted in parallel operation:

(A) The inherent load regulation of the parallel connected supplies is equal to the nominal regulation of the individual supply plus the difference between the nominal voltage setting of the two supplies.

(B) When parallel-connected supplies are used in a systems application, it is advisable to turn on both units simultaneously. The inputs of both supplies should be connected to a single circuit breaker.

(C) When two supplies are operating in parallel, it is not advisable to set either voltage control near zero since this would cause severe damage to the control.

(D) If parallel operation of Trygon power supplies utilizing overvoltage (OV) protection is desired, the following steps should be followed:

1. Disconnect the gate lead from the OV SCR in one of the power supplies.

2. Initially, set the supply with the OV connected to a slightly higher voltage.

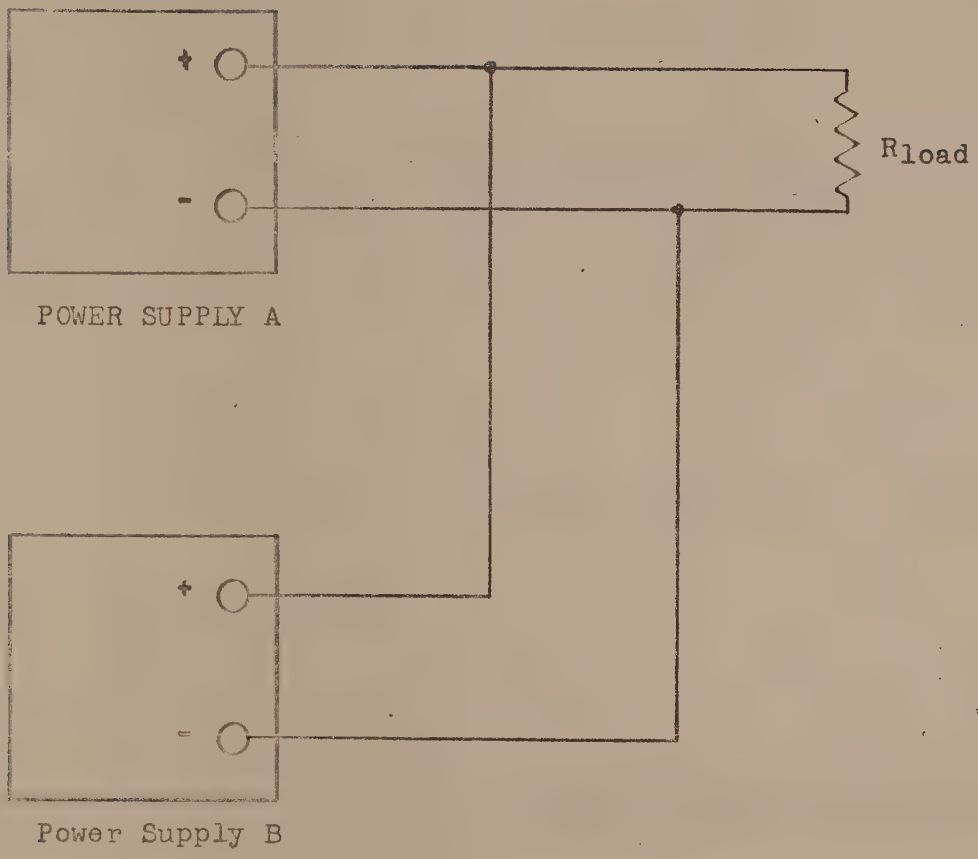

Figure 2-1.

SECTION III - THEORY OF OPERATION

3.1 GENERAL

The purpose of this power supply is to transform and rectify the AC input into a well regulated, stable and adjustable DC output. In performing these functions, the circuitry of the unit may be broken down into four basic sections, which shall be referred to in the following order:

1) Primary Input
2) Reference Supply
3) Series Regulator
4) Comparator and Error Amplifier

3.2 CIRCUIT ANALYSIS

The circuitry has been outlined in simplified form in the Block Diagram (Figure 3-1) located at the rear of this section. As each basic circuit is described, it will be advantageous to refer to the Block Diagram and the Schematic Diagram located at the rear of the Appendice Section of this instruction manual.

3.2.1 Primary Input

Input power is obtained through power transformer T1, full wave rectifier diode sets CR1 and CR2, CR10 and CR11, CR12 and CR13, and filter capacitor C1, C7 and C8. Each rectifier set provides the necessary DC voltages to the various sections of the unit.

When AC power switch S1 is set to AC ON, AC pilot lamp DS1 glows, and AC power is applied to the power transformer. Regulated DC output power is immediately available from the power supply.

3.2.2 Reference Supply

The rectified and filtered voltage from rectifiers CR1 and CR2 and filter capacitor C1 is pre-regulated by Coarse Reference Regulator zener CR3. This provides a stabilized DC voltage to Constant Current Source Q3, whose output is regulated by Precision Voltage Reference zener CR5. Constant Current Source Q1 controls the drive to Q2 and in turn is controlled by Q2. The voltages developed across Constant Current Source References CR4 and CR5 are highly stable reference voltages established at a higher positive potential than the positive output of the supply.

3.2.3 Series Regulator

The DC voltage from diodes CR10 to CR13 is directed through the Series Pass transistors. The conduction of these transistors is controlled by circuitry which causes them to act as variable resistors. Their overall resistance varies in accordance with the need of the power supply to increase or decrease its output voltage or current.

To dissipate power within the Series Pass circuit when power is not being fed into a load, large current handling "throw off" resistors are placed in parallel with the Series Pass transistors. The throw off resistors are placed in a location remote from the Series Pass transistors, to reduce heat concentration and increase transistor life and reliability.

The Series Pass transistors are controlled by several driver stages which amplify signals from the error amplifier.

3.2.5 Comparator and Error Amplifier

The voltage sensing and comparison is accomplished by differential amplifier Q10. A sample of the output voltage on the base of Q10 is compared to the stable reference voltage on the base of comparator Q9. An unbalance caused by a change in voltage at either the negative sensing terminal or across volt-

3.2.5 Comparator and Error Amplifier (Cont'd)

adjustment controls R29 and R30 will appear as a voltage change in the collector of Q10.

This difference voltage is amplified by error amplifier Q6, and is used to regulate the Series Pass transistors via the Series Pass drivers. Error amplifier Q6 has two diode inputs to its base which form an OR gate for error signals. CR7 supplies error signals from the comparator, and CR6 supplies an error signal in the event of a short circuit, or if the power supply is driven into the current limiting mode of operation.

When operating in the current limiting mode, differential amplifier Q3 and Q4 become balanced, causing diode CR6 to conduct, and in turn drives error amplifier Q6 toward cut-off. This signal also causes Q7 to conduct, thereby causing current mode indicator lamp DS2 to glow.

3.3 OPTIONAL FEATURES

3.3.1 Overvoltage (OV) Protection

If the output voltage should rise above the programmed output level, a portion of the signal developed across the OV Sensitivity control will cause the OV Sensor to conduct, which in turn drives the OV Reference into conduction. The output of the OV SCR Driver is applied to the gate lead of the OV SCR, causing it to "fire". "Firing" of the OV SCR cuts off the Series Pass drivers and in turn, the Series Pass circuit.

If the overvoltage condition is caused by a short in the Series Pass circuit, the OV SCR will "fire", causing the OV fuse to open.

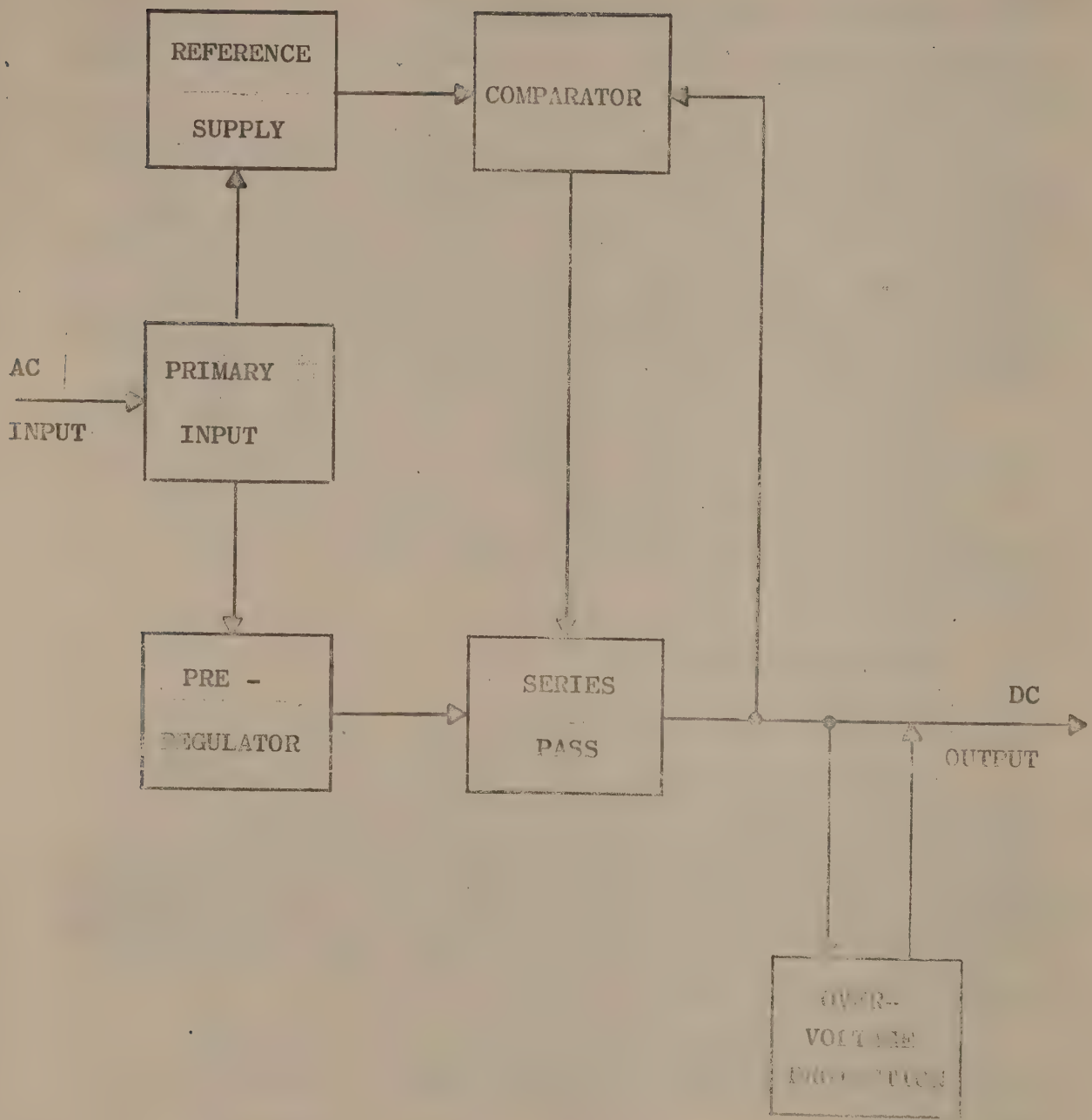

FIGURE 3-1 - BLOCK DIAGRAM

SECTION IV - MAINTENANCE

- WARNING -

High Voltages Are Present
Use Caution

4.1 GENERAL

This power supply is a precision instrument. It is strongly recommended that only experienced troubleshooting personnel perform troubleshooting operations or attempt to repair the unit. If the power supply appears to be malfunctioning at all, the following procedure is recommended for isolating possible defects.

4.2 LOADS AND INTERCONNECTIONS

1. Disconnect all interconnections and loads to which the unit is normally connected.
2. Place shorting links between rear panel terminals 1 and 2, 4 and 5, and 6 and 7. These connections must be securely made, or deterioration of output regulation will occur.
3. Connect a resistive dummy load across output terminals 4 and 10. This load should be of sufficient value to allow the unit to operate at its maximum rated current and voltage output.
4. Apply nominal AC input power to the unit and check for normal operation. Satisfactory operation at this time would indicate that any malfunction previously encountered, is external in nature. All

4.2 LOADS AND INTERCONNECTIONS (Cont'd)

interconnections and loads normally used in conjunction with this power supply should then be carefully checked for electrical defects.

4.3 TROUBLESHOOTING

1. Set VOLTAGE ADJUST and VOLTAGE VERNIER controls fully CW. Using a 20,000 ohms per volt voltmeter or oscilloscope, check the voltages across the various circuit components listed in the TROUBLESHOOTING GUIDE, located immediately before the schematic diagram at the rear of this instruction manual. The sample voltages listed in this guide apply only if the unit is operating at its nominal AC input, and has a dummy load of sufficient size connected across its output to allow operation at maximum rated current and voltage output levels. Any reading which is grossly incorrect indicates that the stage being tested or the one immediately preceding it, is defective. The Block Diagram, Schematic Diagram and appropriate sections of the Theory of Operation will prove helpful in any troubleshooting work. Proper polarity to be observed when testing can be easily obtained from the Schematic Diagram.

2. If voltage checks show no noticeable deviations from the prescribed values, disconnect AC power and proceed with point to point resistance checks across pots, switches, diodes, resistors, transistors in that order.

3. When the trouble is of an intermittent nature such as poor regulation, ripple etc., the use of an oscilloscope to determine dynamic changes will be necessary.

4.3 TROUBLESHOOTING (Cont'd)

The section on Theory of Operation should be consulted to determine circuit performance with varying output conditions.

SECTION V - CALIBRATION

5.1 GENERAL

The following adjustments should be made when necessary to assure optimum operating characteristics and maximum efficiency of the Trygon power supply.

5.2 TEST EQUIPMENT REQUIRED (or equivalent)

(A) Oscilloscope, Tektronix Type 561
(B) Differential Amplifier Plug In, Tektronix Type 63
(C) Time Base Plug In, Tektronix Type 67
(D) Differential VTVM, Fluke Model 825A
(E) AC VTVM, Hewlett Packard Model 400D
(F) VOM, Simpson Model 260
(G) Variable Auto transformer, Powerstat Type 3PN136 (20 Ampere rating)

5.2.1 Shorting Link Application

For test purposes, shorting links should be connected across terminals 1 and 2, 4 and 5 and 6 and 7 to provide local sensing and local voltage programming. To reduce pick up, shielded wire must be used for all connections between test equipment and the power supply being tested. To prevent ground loops, it is important that only one ground connection be made, as shown in Figure 5-1 and Figure 5-2. Tighten all terminal connections as securely as possible, and set all front panel controls fully CW.

5.3 CALIBRATION PROCEDURE

5.3.1 Voltage Adjust Control

5.3.1 Voltage Adjust Control (Cont'd)

A) Maximum Voltage

Set front panel VOLTAGE ADJUST and VOLTAGE VERNIER controls fully CW. Adjust Maximum Voltage control R24 to obtain an output voltage 0.5 VDC in excess of the maximum rated output voltage.

B) Minimum Voltage

Set front panel VOLTAGE ADJUST and VOLTAGE VERNIER controls fully CCW. Adjust Minimum Voltage control R28 to obtain a negative output voltage of 0.1 VDC.

C) Readjustment

Adjustment of either Maximum Voltage control R24 or Minimum Voltage control R28 will have an effect upon the other. Therefore, these controls should be readjusted if necessary, as outlined in preceding paragraphs 5.3.2 (A) and (B), upon initial completion of this adjustment.

NOTE

If partial rotation of the VOLTAGE ADJUST controls produces no apparent change in indicated output voltage, further rotation of these controls should not be attempted. Rotation of these controls fully CCW with little or no output voltage regulation can result in damage to the controls, the load, or both. Set the AC POWER switch to OFF, and proceed with the troubleshooting outlined in Section IV (MAINTENANCE) of this instruction manual.

Set front panel VOLTAGE ADJUST and VOLTAGE VERNIER controls fully CCW and observe that the voltage indicated on the unit and test voltmeters drops slightly below the zero setting of the meters. The output voltage should be approximately negative 200 MV. Reset voltage controls fully CW.

5.3.2 Current Adjust Controls

A) Maximum Current

Connect a test ammeter having a full scale current indicating capacity of 150% that of the rated current output across the output terminals of the power supply. (Set all front panel controls fully CCW). Apply power to the unit under test and slowly rotate CURRENT ADJUST control fully CW. Observe that the maximum current obtainable is approximately 105% that of the maximum rated current output. If it is not possible to achieve 105% of the maximum rated current output, adjust Maximum Current control R41 until that value is attained. Set AC Power Switch to OFF.

Connect a suitable load resistance across the output terminal connections. The load resistance must be able to dissipate the rated power of the unit (P = IE) and must be of sufficient value to yield the rated output current when the rated voltage is applied. Set AC Power Switch to ON. Note the voltage indicated on the Differential VTVM. Disconnect the resistive load from the output and observe the voltage indicated on the Differential VTVM. The maximum change in output voltage should not exceed by more than 0.01% or 3 mv (whichever is greater) that of the output voltage indicated with the load resistance applied across the output terminals.

If it is not possible to maintain the load regulation as stated in the preceding paragraph, readjust Maximum Current control R41 slightly and recheck the load regulation.

5.3.3 Constant Voltage Operation

A) Load Regulation

5.3.3 Constant Voltage Operation (Cont'd)

With the equipment connected as shown in Figure 5-1, connect a suitable load resistance across the Output terminal connections. The load resistance selected must be able to dissipate the rated power of the unit (P = IE) and must be of sufficient value to yield the rated output current when the rated voltage is applied. Note the voltage indicated on the Differential VTVM. Disconnect the resistive load from the output. The maximum change in output DC voltage indicated on the Differential VTVM should not exceed by more than 0.01% or 3 mv (whichever is greater) that of the output voltage indicated with the load resistance applied across the output terminals.

B) Line Regulation

Place the resistive load across the output and note the voltage indicated on the Differential VTVM. Vary the AC input power 10% above and below the nominal AC input level. The maximum change in output voltage should not exceed by more than 0.01% or 2 mv (whichever is greater) that of the output voltage measured at either extreme of the AC input.

C) Ripple Voltage

In order to reduce pickup, shielded test leads should be used in making ripple measurements. With the resistive load connected across the output terminals, measure the AC ripple with the AC VTVM. Vary the AC input power 10% above and below the nominal AC input level. The maximum ripple amplitude should not exceed 0.5 mv RMS.

5.3.4 Constant Current Operation

A) Load Regulation

With the equipment turned off, disconnect the resistive load from the output terminals. Connect a small current sensing resistor in series with the resistive load and then connect the load back across the output terminals. Selection of the proper value for the current sensing resistor may be easily made using the formula $R_S = \frac{I}{I_R}$ where R_S = Value of Current Sensing Resistor and I_R = Rated Load Current. Connect the equipment as shown in Figure 5-2, and apply power to the power supply.

Vary the VOLTAGE ADJUST controls and resistive output load as necessary, to achieve rated current and voltage output. Decrease the load resistance until current meter reading exceeds full scale indication. Rotate CURRENT ADJUST control CCW to return the current meter reading to full scale. Observe that the output voltage has decreased from its previous full scale reading, and that increasing the VOLTAGE ADJUST controls has no effect upon the output voltage or current. This indicates that the unit is now operating in the Constant Current mode.

5.3.5 Overvoltage (OV) Sensitivity (Optional)

The sensitivity of the Overvoltage Protection circuit is determined by the setting of the Overvoltage Sensitivity control. This control is factory preset to cause a short circuit to be applied across the output of the unit if the output voltage attempts to rise more than 5% or 1.5 volts above the programmed voltage.

Although an internal control, the OV Sensitivity control is not "solder locked" in place as are the other internal controls, but may be varied to suit the individual needs of the

5.3.5 Overvoltage (OV) Sensitivity (Optional) (Cont'd)

user. This control may be varied from outside the unit by inserting a screwdriver through one of the ventilation holes in the top of the power supply case.

To determine the proper point at which the OV Sensitivity control should be set to automatically shut the unit off, connect the output of a second power supply having a higher output voltage capability, in parallel with the unit under test. Set the output of the second unit 10% higher than that of the first unit. Adjust the OV Sensitivity control until the unit under test automatically shuts itself off.

5.3.6 Test Set-Up

The equipment should be connected as shown in Figures 5-1 or 5-2 for testing in either the Constant Voltage or Constant Current modes of operation.

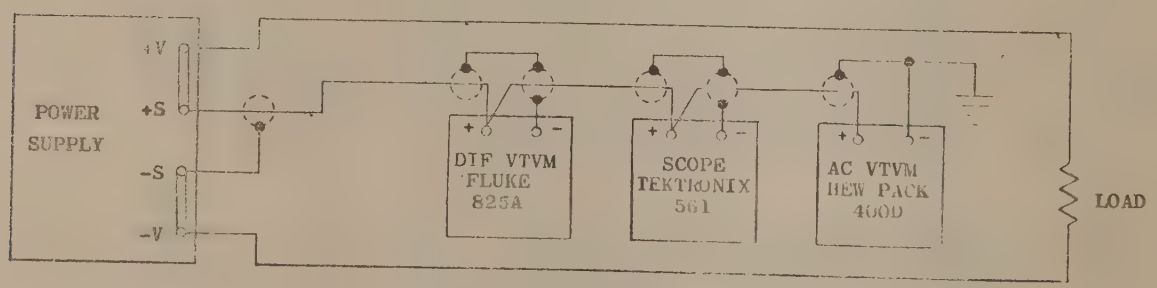

FIGURE 5-1
CONSTANT VOLTAGE OPERATION

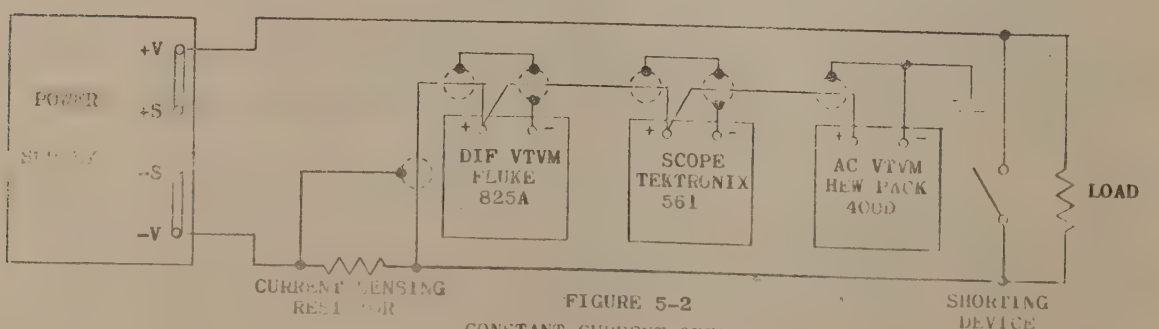

FIGURE 5-2
CONSTANT CURRENT OPERATION

Semi-conductors commonly used in Trygon power supplies are available for replacement or spare parts use under the following Trygon, commercial manufacturer or JEDEC part number

TRANSISTORS

S E M I - C O N D U C T O R P A R T N U M B E R S

TRYGON STOCK NO.	TRYGON or MFR P/N	JEDEC EQUIVALENT
700000	See 705067	
700001	See 700002	
700002	700002	2N3638A
700010	TR346	2N1556
700020	See 705067	
700030	TR361	2N652
700040	TR375	2N1533
700047	700047	2N4238
700050	700050	2N657A
700070	TR951	2N2527
700080	700080	2N3055
700083	700083	2N3232
700085	700085	2N3442
700115	See 705067	
700120	700120	2N1530
700130	700130	2N1554
700140	700140	2N1560
700160	700160	2N2140
700180	700180	2N2714
700182	700182	2N3566
700191	700191	2N4912
700195	700195	2N3441
700196	700196	2N4912
700197	700197	2N3738
700200	700200	2N2139
700205	700205	2N3440
700400	700400	2N3441
700401	700401	2N3771
700402	700402	2N3772
700410	700410	2N3442
700412	700412	2N3568
700413	700413	2N3644
700415	700415	2N3585
700417	700417	2N4918
700420	700420	2N3584
700429	DTS411	DTS411
700430	DTS413	DTS413
700431	DTS423	DTS423
700502	700502	2N5037
700508	700508	2N5240
705018	705018	2N3416
705067	705067	2N2905A
705068	705068	2N2219A
705069	705069	2N4340
705070	705070	2N3233
705071	705071	2N3447
720145	UJ25	2N2647

Semi-conductors commonly used in Trygon power supplies are available for replacement of spare parts use under the following Trygon, commercial manufacturer or JEDEC part number

RECTIFIERS

S E M I - C O N D U C T O R P A R T N U M B E R S

TRYGON STOCK NO.	TRYGON or MFR P/N	JEDEC EQUILVALENT
705014	705014	2N1929
720000	C35B	2N685
720005	C33F	
720010	C35F	2N682
720015	C30F	
720030	C50AX258	
720040	C50B	2N1913
720043	C50C	2N1915
720050	C50F	2N1910
720053	C60A	2N2025
720060	E016	
720075	E0130	
720110	SV515	1N823
720131	720131	1N3618
720132	720132	1N3616
720133	720133	1N3619
720135	720135	1N3495R
720136	720136	1N3621
720137	720137	1N3622
720173	1N759A	1N5242B
720175	1N746A	1N5226B
720181	1N751A	1N5231B
720182	1N754A	1N5235B
720185	1N752A	1N5232B
720192	1N753A	1N5234B
720196	1N755A	1N5236B
720241	1N1360A	1N2986A
720262	1N2163A	1N2163A
720263	1N2163A	1N2163A
720273	SCR285-2	
720274	SCR285-3	
720275	SCR285-4	
720277	SCR285-5	
720280	SCR93-2	
720290	SCR93-3	2N2573
720300	SCR93-4	2N2574
720301	SCR93-5	2N2677
720303	SCR93-7	
720330	70H10	
720335	40HF10	1N1184A
720350	70H20	1N4136
720383	1N4585	1N4585
720384	1N4384	1N4384
720387	1N4740A	1N4740A
720388	1N4733A	1N4733A
720394	1N964B	1N5243B
720395	1N965B	1N5245B

ELECTRONICS INC.

Semi-conductors commonly used in Trygon power supplies are available for replacement of spare parts use under the following Trygon, commercial manufacturer or JEDEC part number

RECTIFIERS

S E M I - C O N D U C T O R P A R T N U M B E R S

TRYGON STOCK NO.	TRYGON or MFR P/N	JEDEC EQUILVALENT
720427	See 720136	
720440	TR4148	1N4148
720443		1N3208
720450	See 720456	1N3659
720453	See 720456	1N4719
720454	MR1031A	1N4720
720455	MR1032A	1N4721
720456	MR1034A	1N4722
720458	See 720456	
720459	1N758	1N758
720397	1N2164A	1N2164A
720460	1N961B	1N5240B
720468	1N968	1N5250B
720473	1N821	1N821
720488	60HF60	1N2138
720489	C46E	
725008	C180A	
725019	1N765A	1N5241B
725056	MR1220SL	
725071	1N3515A	1N5236B
725076	1N3616	1N3616
725077		1N3262R
725079	MCR2835-4	
725081	MCR216R-2	
725082	MCR216R-3	
725083	MCR216R-5	
725085	MCR216R-6	
725087	MCR3918-1	2N5168
725138	725138	2N4441
725139	See 725142	
725140	MAC 3-2	
725142	725142	2N4442
725143	Y0525	
725144	40526	
741001	741001	2N4990

MANUFACTURER'S CODE LISTING - ELECTRICAL PARTS

1) The numbers designated in the SPARES column of the following ELECTRICAL PARTS LISTING indicate the recommended spare parts requirement for support of this equipment for a period of one year.
2) The code designations listed in the MFR column of the ELECTRICAL PARTS LISTING have been assigned to the following manufacturers:

CODE	MANUFACTURER	CODE	MANUFACTURER
A-B	ALLEN BRADLEY	LEE	LEECRAFT
ARN	ARNOLD	MILW	MILWAUKEE
BUSS	BUSS	MOTO	MOTOROLA
CARL	CARLING	PHAO	PHAOSTRON
CD	CORNELL DUBILIER	RCA	RADIO CORPORATION OF AMERICA
CLAR	CLAROSTAT	ROT	ROTRON
CORN	CORNISH	SAGE	SAGE
CTS	CHICAGO TELEPHONE SUPPLY	SANG	SANGAMO
ERIE	ERIE	SPRA	SPRAGUE
GE	GENERAL ELECTRIC	STEV	STEVENS
GI	GENERAL INSTRUMENTS	TRAN	TRANSITRON
HOYT	HOYT	TRY	TRYGON
IREC	INTERNATIONAL RECTIFIER CORP.	UNI	UNITRODE
IRES	INTERNATIONAL RESISTOR CORP.	WILG	WILGREEN
OHM	OHMITE	WL	WARD LEONARD
SCHW	SCHWEBER	SEMC	SEMCOR
HW	HONEYWELL	TRU	TRUOHM

LIST OF ELECTRICAL PARTS - MODEL HH 32-1.5

Designation	Component	MFR	Part Number	Spares	Stock No.
C1	Capacitor, 500 MFD, 75V	GE	43F1109CA8	1	820010
C2,5,12	Capacitor, .01 MFD, 600V	ERIE	811Z5V103P	2	800090
C3	Capacitor, .0033 MFD, 600V	ERIE	CK62AW332M	1	800025
C4	Capacitor, .001 MFD, 600V	ERIE	CK62BX102M	1	800006
C6,10	Capacitor, 1 MFD, 150V	MALL	Type TTXE	2	810001
C7	Capacitor, 18 MFD, 100V	SPRA	40D186F100DH4	1	810020
C8	Capacitor, 3300MFD, 100V	TRY	820183	1	820183
C9	Capacitor, 500 MFD, 75V	TRY	820223	1	820223
C11	Capacitor, 34 MFD, 15V	MALL	TTXE	1	810057
CR1,2,6,7,8,9, 12-15,17	Diode	GI	1N4384	6	720384
CR18	Diode	TRY	TR4148	1	720440
CR3	Diode, Zener	HOFF	1N1360A	1	720241
CR4,16	Diode, Zener	TRAN	1N751A	2	720181
CR5	Diode, Zener	MOTO	Z0132	1	720263
CR10,11	Diode	TRY	720131	1	720131
DS1	Pilot Light	LEE	36N1311-6	1	770024
DS2	Light Indicator	IND. DEV.	2190A87	1	770023

LIST OF ELECTRICAL PARTS - MODEL HH32-1.5					
Designation	Component	MFR	Part Number	Spares	Stock No.
F1	Fuse 5 Amp.	BUSS	MDL10	5	870200
M1	Meter, 1 Amp.	Ammon	Type AP-1	1	750383
M2	Meter, 50V	Ammon	Type AP-1	1	752630
P1	Cord Line	CORN	18 3		941000
Q1,3,4,5,7,8,9, 10	Transistor	GE	16A507	6	700180
Q2,6	Transistor	TRY	TR1132	2	700000
Q11,12	Transistor	TRY	TR1495	2	700085
Q13	Transistor	TRY	TR1593	1	700195
Q14	Transistor	TRY	TR2195	1	700110
R1	Resistor, 200Ω, 5W, 5%	WL	5XM200	1	640389
R2	Resistor, 3.95K, .5W, 1%	IRC	Type Cecto	1	620510
R3	Resistor, 47KΩ, .5W, 10%	AB	RC20GF473K	1	610340
R4	Resistor, 1.18KΩ, .5W, 1%	IRES	CECTO	1	620320
R5	Resistor, 150Ω, .5W, 1%	IRES	CECTO	1	620050
R6,7,9,19,23	Resistor, 750Ω, .5W, 1%	IRES	CECTO	5	620250
R8,R38, R22	Resistor, 100Ω, .5W, 10% Resitor, 330Ω, .5W, 10%	AB AB	RC20GF101K RC20GF331K	2 1	610070 610120

LIST OF ELECTRICAL PARTS - MODEL HH32-1.5

Designation	Component	MFR	Part Number	Spares	Stock No.
R10,20,21	Resistor, 1.96KΩ, .5W, 1%	IRES	CECTO	3	620402
R11,36	Resistor, 470Ω, .5W, 10%	AB	RC20GF471K	1	610140
R12	Resistor, 4.7KΩ, .5W, 10%	AB	RC20GF472K	1	610250
R13,33,34	Resistor, 1KΩ, .5W, 10%	AB	RC20GF102K	2	610180
R14	Resistor, 10KΩ, .5W, 10%	AB	RC20GF103K	1	610290
R15	Resistor, 100KΩ, .5W, 10%	AB	RC20GF104K	1	610350
R16	Resistor, 560Ω, .5W, 10%	AB	RC20GF561K	1	610150
R17	Resistor, 402Ω, .5W, 1%	IRES	CECTO	1	620140
R18	Resistor, 1.5KΩ, .5W, 1%	IRES	CECTO	1	620360
R24,R44	Potentiometer, 250Ω, 1.5W	CTS	110	2	600102
R28	Potentiometer, 150Ω, 1.5W	CTS	110	3	600071
R25	Resistor, 511Ω, .5W, 1%	IRES	CECTO	1	620180
R26	Resistor, 200Ω, .5W, 1%	IRES	CECTO	1	620070
R27	Resistor, 50Ω, 3W, 3%	SAGE	1300S50-3	1	630220
R29,30	Potentiometer, 6K, 100/2W, Dual	TRY	605040	2	605040
R31	Resistor, 3KΩ, 10W	TRU	FR10	1	640542
R32	Resistor, 2.5K, 5W, 5%	WL	Type 5X	1	640544
R35	Resistor, 2.2KΩ, .5W, 10%	AB	RC20GF222K	1	610210
R37,47	Resistor, 150Ω, 50W	IRC	Type 4D	2	650575
R39	Potentiometer, 125Ω, 2W, 10%	TRY	B1647	1	600060
R40	Resistor, 301Ω, .5W, 1%	IRES	CECTO	1	620110

LIST OF ELECTRICAL PARTS - MODEL HH32-1.5

Designation	Component	MFR	Part Number	Spares	Stock No.
R41	Potentiometer, 500Ω, 1.5W	CTS	110	1	600146
R42	Resistor, 1.0Ω, 25W	IRC	Type 2D	1	650115
R43	Resistor, 604Ω, .5W, 1%	IRES	CECTO	1	620210
S1	Switch, DPST	CARL	2BK63-73	1	880090
T1	Transformer	TRY	HHT50-1.0	1	509043

LIST OF ELECTRICAL PARTS - OVERVOLTAGE

Designation	Component	MFR	Part Number	Spares	Stock No.
C15	Capacitor, .047 MFD, 250V	COMA	MET MYLAR	1	800147
CR20	Diode, Zener	TRAN	IN751A	1	720181
CR24	Diode	TRY	720123	1	720123
CR25	Rectifier, Silicon Control	GE	C30F	1	720015
F2	Fuse	BUSS	AGCZ AGC-2	5	870050
Q20	Transistor	GE	16A507	1	700180
Q21	Transistor	TRY	705067	1	705067
Q23	Transistor	TRY	TR1132	1	700000
R50	Resistor, 1.5KΩ, .5W, 1%	IRES	CECTO	1	620360
R51	Resistor, 470Ω, .5W, 10%	AB	RC20GF471K	1	610140
R52	Resistor, 10KΩ, .5W, 10%	AB	RC20GF103K	1	610290
R53	Resistor, 4.7KΩ, .5W, 10%	AB	RC20GF472K	1	610250
R54,R56	Resistor, 1KΩ, .5W, 10%	AB	RC20GF102K	1	610180
R55	Potentiometer, 5KΩ, 1.5W, 20%	CTS	110	1	600290

TROUBLESHOOTING GUIDE

SECTION	COMPONENT	FUNCTION	DC VOLTAGE ± 10%			
			7-4	14-3	32-1.5	50-1
REFERENCE	CR3	Reference Reg.	24.0	24.0	24.0	24.0
	CR4	Con. Curr. Ref.	5.1	5.1	5.1	5.1
	CR5	Voltage Ref.	9.5	9.5	9.5	9.5
	CR16	Diff. Offset Ref.	5.1	5.1	5.1	5.1
	Q1,Q2	Con. Curr. Source	3.3	3.3	3.3	3.3
SERIES REG.	C7	Output Filter	21.0	28.0	46.0	64.0
	Q11,Q12	Series Pass	10.0	10.0	10.0	10.0
	Q14	Driver	18.0	18.0	18.0	18.0
	R31	Output Resistor	28.0	42.0	82.0	115.0
	R36	Bias Resistor	7.0	7.0	7.0	7.0
COMPARATOR AND ERROR AMPL	Q6	Error Amplifier	2.5	2.5	2.5	2.5
	Q9,Q10	Output Comparator	4.0	4.0	4.0	4.0
	R18,R19	Reference Divider	9.5	9.5	9.5	9.5
	R23	Mode Resistor	2.7	2.7	2.7	2.7

NOTES:

1. Voltage listings assume operation of unit at nominal AC input and rated DC output.
2. Base to emitter voltages of Series Regulator transistors must be positive for conduction.
3. Series Pass voltage measured from Q11 collector to Q12 emitter.
4. Series Pass Driver voltage measured between Q14 collector and emitter.

MODEL NO.	HH50-1
PROD. DWG. NO.	21910
TITLE	COMP-BD. TB3
REV.	D
DATE	

#068678 → RAISE 5 WATT RESISTORS OFF BOARD 1/8"

W/V10-116 ---27
W/YEL-145-OV -26
W/BN-119 -25
W/OR-148-OV -24
W/BL-150-OV -23

V10-126 -22
W/RD-125 -21
WHT-124 -20
GN-109 -19
W/GN-107 -18
BL-106 -17
W/BK-129 -16
Y-108 -15
BN 105 -14

GY-127 -13
W/GY-128 -12

R24 #600102 250Ω 1.5W
R25 5.1K Ω-1/2
R21 1960Ω-1/2
R22 330Ω 1/2
R20 1960Ω-1/8
C5 .01
R18 1.5KΩ-1/2
Q10 TA1503
Q9 TA1003
C4 .001
C7 .0033
R16 560Ω 1/2
Q8 Q7 1/2A500
R14 10KΩ-1/2
Q6 1132
Q5 1/2A500
R17 402Ω-1/2
R13 1KΩ-1/2
R12 4.7KΩ-1/2
R11 470Ω-1/2
R15 100KΩ-1/2
CR6 4384
CR7 4384
CR8 4384
R23 750Ω-1/8
R24 750Ω-1/8
R26 200Ω-1/8
R27 50Ω-3
C9 500MF-75V
STRAP 95034
C11 34MF-15V
CR9 4384
R7 750Ω-1/8
C2 .01
R9 750Ω-1/8
R10 1960Ω-1/8
R8 100Ω-1/2
R6 750Ω-1/8
CR5 NO 132
R4 1150Ω-1/8
R5 150Ω-1/2
CR4 4384
R3 47KΩ-1/2
R2 9950Ω-1/8
Q2 1132
Q1 1/2A500
CR2 4384
CR1 4384
R1 200Ω-5
C1 500MF-75V
STRAP 95034
#600102 R44 250Ω 1.5W
J#200 1 RD-
W/RD- 2 J#202
W/BK-114 3 DC
W/RD-131 4 DC
R32-2.5K-5
MACHINE OFF BOARD
5 6 7 8 9 10 11 12
P-110 DC
.2Ω-3
R45
TURRET #960476
W/VIO-115 DC
YEL- J#201
W/BL-144-OV
W/OR-134
BL-130 DC
C12 10
C10 18MF 100V
R28 #600111 150Ω 1.5W
CR17 4384
R38 100Ω-1/2
CR14 4384
CR15 4384
R36 470Ω-1/2
R41 500Ω 1.5W BK/5791
CR16 1751A
C6 1.0-150V
Q4 1/2A500
Q3 1/2A500
R40 301Ω-1/8
R43 604Ω-1/8
Q14 2195
R34 1KΩ-1/2
R32 1K-1/2
R35 2.2KΩ-1/2
CR12 4384
CR13 4384
OR-4 AC
W/OR-5 AC

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